Introduction. The issue of seismicity of the Transcarpathian depression as the main seismogenic structure of the Ukrainian Carpathians has been studied for many decades. Significant seismic events that have taken place here over the past decade (Tyachiv series of earthquakes in 2015) are sowing alarm among the population and remind of the general seismic danger in this region. However, studies of the seismicity of the Transcarpathian depression are usually limited to the territory delineated by the state border of Ukraine. At the same time, the territories adjacent to the Transcarpathian depression are characterized by high seismic activity, which is genetically related to the fault-block structure of the region's crust. In this regard, special attention is drawn to the Maramures depression, which is partly located in the Inner and part of the Flysch Carpathians.

Methods of investigation. The study of seismicity was carried out by empirical-theoretical method. At the initial stage, seismic observations were collected using instrumental observations (Kostiuk et al., 1997) and online bulletins (ISC, 2016) for the Transcarpathian depression and the Maramures basin and adjacent territories. The next step was to build a map of the spatial distribution of epicenters and analyze their relationship with the tectonic structure of the region.

Initial and geological data. The section of the Transcarpathian depression, which passes into the territory of Romania (Okna-Shugatag-Birsana) is a part of the Maramures basin, the seismic activity of which has not been studied enough. The Maramures depression is a synclinorium of complex configuration, bordering the Marmaros crystal massif in the east, the Lepus Mountains in the west and the Transylvanian depression in the south. Its length is about 120 km; width varies between 50-60 km. It is divided into a number of tectonic units by a system of multidirectional tectonic faults (mainly downthrows). The largest of them are the Petrov block, the Viseul de Jos graben, the Borsch graben, the Bistra depression of the Shetrev structure and Birgeu. The part of the Transcarpathian depression that extends into the territory of Romania is called Okna-Shugatag-Birsana (Romanian: Ocna Șugata). From the east it is limited by the Petrov block, which is divided into two parts: one is immersed under the Neogene trough of Transcarpathia, and the other, together with the Bistra depression, turns into a flysch (? shopurski?). The Romanian section of the Transcarpathian depression (Hlushko, 1968) is characterized as a graben-like structure formed on the southwestern slope of the Marmaros crystal massif.

Results of investigations. Instrumental observational data (Kostiuk et al., 1997) as well as the online resource of the International Seismological Center (ISC, 2016) were used to analyze the spatial-deep distribution of earthquakes in the period 1960–2015.. The magnitude, depth and energy class of earthquakes were taken into account in the selection. During the considered time period, 78 earthquakes with energy class $Kp \geq 7$ were considered on the territory of the study. Smaller values of Kp were not taken into account, as such earthquakes are difficult to distinguish from industrial explosions. The spatial distribution of earthquake epicenters is characterized by certain patterns (Figure 1). Isolated seismic events are recorded in the cover areas in the north-eastern part of the region and are probably related to the contact of the Folded Carpathians and the Eastern European platform. The main number of earthquakes is grouped in such structural and tectonic units as the Solotvyno depression (Ukraine) and the Maramures depression (Romania), as well as within the Vyhorlat-Hutyn volcanic ridge. There is also a tendency of earthquake epicenter concentration ($Kp > 7$) to tectonic faults of northeastern and northwestern extension and their intersections, as well as areas of contact of Alcapa, Tisza plates with tectonic structures of Solotvyno depression and Maramures basin. About the distribution of hypocenters with depth can be judged from Figure 2 where the conditional profile II-II was designed hypocenters of earthquakes of class $K > 7$ (Figure 2). Profile II-II crosses the Maramures Basin from southwest to northeast parallel to the Hutsul deep fault, as well as to the seismological profile RP-5 (on the territory of Ukraine). The starting point (0) is the intersection of line I-I with the meridional fault.

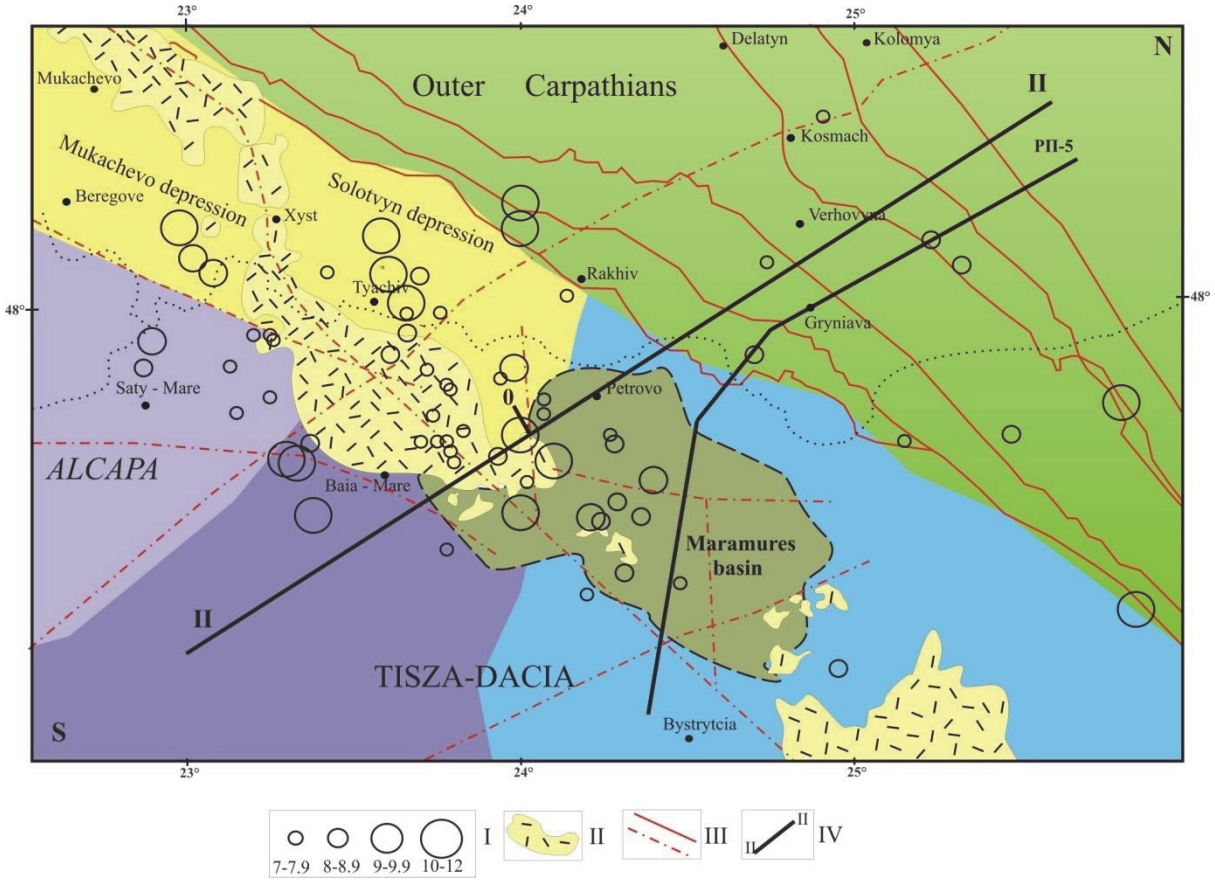

Figure 1 *Scheme of location of earthquake epicenters of the Maramures basin and adjacent territories for 1960-2015 on a tectonic basis (Hlushko, 1963). I - energy class of earthquakes (Kp); II - Vyhorlat-Hutyn volcanic ridge; III - boundary tectonic zones and faults of the crust; IV – line of profile II-II and RP-5*

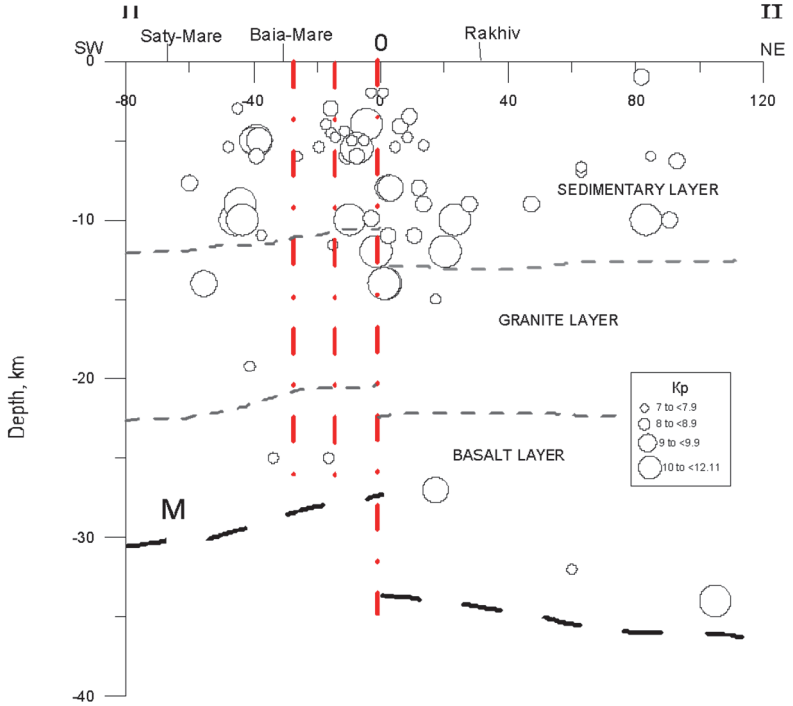

Figure 2 *Distribution of hypocenters of earthquakes in the lithosphere of the Maramures ression along the line II-II for the period 1960-2015*

According to the deep distribution of hypocenters, there are three floors (layers) of earthquake spread. The boundaries between the layers of the earth's crust were taken on the basis of the seismological profile RP-5. The first is the sedimentary layer, where most of the hypocenters of earthquakes are located at depths of 2-7 km. The second floor of the distribution is the foundation and top of the granite layer, where at depths of 8 to 15 km there are hypocenters of earthquakes of the highest energy class for the region (K = 11-12). It should be noted that at the boundary of the sediment-granite layer, the increase in the depth of earthquake foci is accompanied by an increase in the energy class of earthquakes. The third floor (basalt) is characterized by a small number of seismic events, and the depth of their distribution is 18-34 km. When analyzing the peculiarities of the distribution of earthquake hypocenters in the Transcarpathian depression (Maksymchuk et al., 2014), it is shown that a significant number of energy class events (K = 11-12) occurred in the sedimentary layer at depths of 5–10 km. While in the Maramures basin earthquakes of energy classes (K = 11-12) were recorded in the range of depths of 8-15 km at the boundary of the sedimentary and granite layers. This indicates certain differences in the structural and tectonic structure of both depressions. The distribution of the number of earthquakes with Kp≥7 in time for the Maramures depression for 1960-2015 is shown in Figure 3. The small number of earthquakes in 1960-2000 is probably due to the lack of the necessary dense network of seismic stations. In fact, earthquake catalogs for this area do not present earthquakes with Kp ≤ 7. The number of earthquakes with K≥7 has risen sharply since 2000. At the same time, their extreme falls in 2001, as well as in 2012 and 2015. Interestingly, the released energy also marked the interval 1964-1979, where the level of total energy reached 10^{11} J. At the same time, groupings of earthquakes with an energy of 10^{10} - 10^{11} J in time intervals: 1963-1964, 1970-1972, 1978-1980.

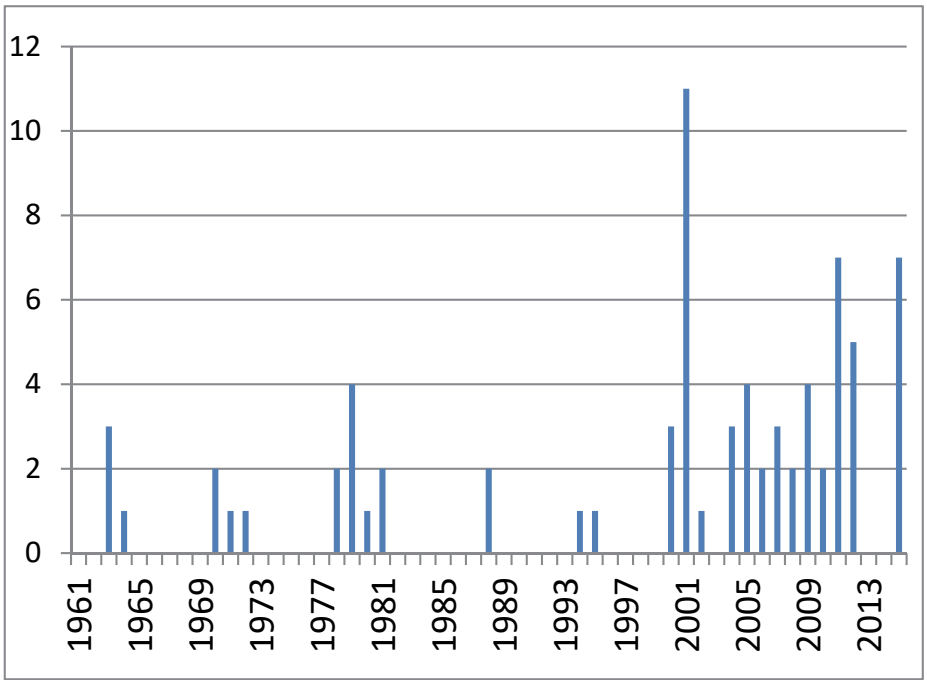

Figure 3 *Histogram of the distribution of the number of earthquakes (K> 7) of the Maramures basin and adjacent territories for the period 1960-2015*

The time distribution of the total energy of earthquakes in the study area differs from the number of events (Figure 4). The energy (E) for each event was determined by the ratio $E = 10^K$ (J), where K is the energy class of the earthquake. The total annual energy of earthquakes is found by summing the energy of all earthquakes of energy class Kp> 7, which occurred in the Maramures depression and surrounding areas during the calendar year. As shown in Figure 4, the energy level ranges from a minimum of 10^7 J in 2002 to a maximum of 10^{12} J in 2011. We also see periods when earthquakes with Kp≥7 did not occur in the region. This situation may be due to a lack of data.

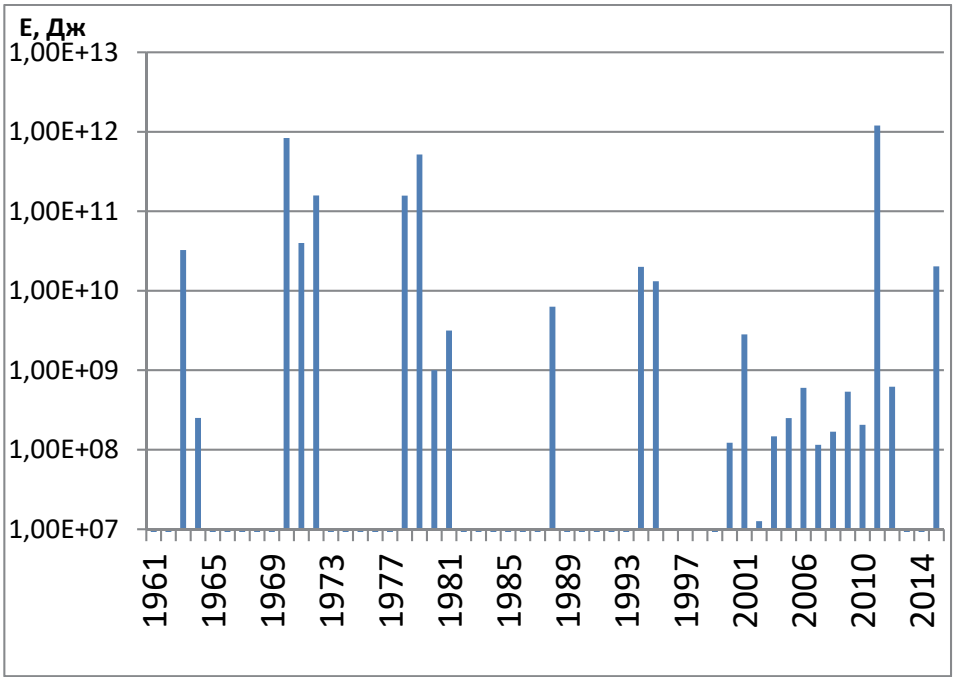

Figure 4 *Histogram of the total released energy of earthquakes (K> 7) of the Maramures basin and adjacent territories for the period 1960-2015*

We can mark off two large time intervals (periods) of oscillations (distribution) of energy. The first period from 1963 to 2001 is characterized by energy in the range of 10^{10} - 10^{11} J / year, the second - from 2004 to 2015 is characterized by energy in the range of 10^{8} - 10^{11} J / year. The maxima of the released energy of the first period are fixed on 10.07.1970 (47.80 25.80; M 4.4; h = 34 km) and 30.03.1979 (47.70 23.33; M 4.2; h = 10 km) practically at the level of 10^{12} J. Energy extremes of the second period (2004 and 2015) are associated with earthquakes in the contact of the Folded Carpathians and the Eastern European platform.

Conclusions. Thus, the spatio-temporal distribution of the seismicity of the Transcarpathian depression and the Maramures depression is closely related to the fault-block structure of the foundation. The epicenters of earthquakes of both structures are mostly confined to tectonic faults of different ranks and to the nodes of their cross sections. In the deep distribution of hypocenters, three levels (layers) of their distribution are distinguished. The seismic activity of the Transcarpathian depression and the Maramuresh basin reflects the geodynamics of the Carpathian region at the present stage of the development of the Carpathian mountain system.

References

Hlushko, V.V. [1968] Tectonics and petroleum potential of the Carpathians and adjacent depressions. Moscow, Nedra Publ., 264. (in Russian).

International Seismological Centre [2016], Internatl. Seismol. Cent., Thatcham, United Kingdom http:// www.isc.ac.uk

Hlushko, V.V. [1963] Tectonic map of the Ukrainian Carpathians in scale 1:1000000 – 1963. (in Russian).

Maksymchuk, V.E., Pyrizhok, N.B., Pronyshyn, R.S. and Tymoschuk, V.R. [2014] Some peculiarities of seismisity Transcarpathians. *Geodynamics 2(17),* 139-149. (in Ukrainian).

Kostiuk, O., Sahalova, E., Rudenska, I., Pronyshyn, R. and Kendzera, O. [1997] Catalogue of earthquakes in the Carpathian region for the period 1091-1990. Proceedings of the Shevchenko scientific society, Lviv. 121-137. (in Ukrainian).